Georgia Tech NEETRAC
National Electric Energy Testing, Research and Applications Center

NEETRAC NEWS

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In This Issue...

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An Enjoyable and Challenging Career

Written by Thomas Champion

For those who do not know, after 25 years with NEETRAC, I retired at the end of February 2021. Those 25 years provided many opportunities to work at a job that I enjoyed. The driving force for my career was an enjoyment in solving problems others could not by applying the basic principles of physics in novel ways. Although I worked in many areas, the subject of forensics, determining how and why products fail, was always the field of choice and the one that provided the most pleasure. A simple problem will always stand out.

Serving as Chair of the IEEE Insulated Conductors Committee and a lifetime of involvement with that committee was another highlight, offering the opportunity to participate in and lead an organization that serves the technical needs of our industry. The variety of people, the diversity of viewpoints, the range of problems addressed, and the willingness of those in attendance to participate make the organization an outstanding place to learn and grow in your career. Friendships are developed that last a lifetime. Information is exchanged that allows each person to grow and the entire industry to improve. I highly recommend that utilities participate in this committee and make their needs known through active involvement, not just attendance. Utilities are under-represented in many of the working and discussion groups. Their involvement could meaningfully change many standards to more fully address industry needs.

For much of my career, I was known as a generalist, although my degree was in Electrical Engineering. Experience provided some knowledge in a lot of different areas, with more in-depth knowledge in a few areas. Surprisingly to me, I was frequently able to recover knowledge I gained in college, even though I had not used it in many years. Perhaps that was an indication of my collegiate efforts to understand the concepts presented and not just reproduce the solution techniques. This tended to make things stick with me over time while amazing some colleges. I always retained an interest in learning new things, which fit in perfectly with a research environment.

Luckily, over most of my career, I reported to managers who were willing to provide the tools and opportunities needed for success. We could choose our own path, make decisions, and accept the consequences of those decisions. Independence without micro-management gave NEETRAC a diversity in the early days that drove the success of the organization and the job satisfaction of the employees. Each of us approaches problems in a different way. Building on that diversity and encouraging group problem solving were factors in NEETRAC's success. Hopefully, that will continue to be the case in the future, driving both customer and employee satisfaction.

A Blast from the Past

In a blast from NEETRAC past, ten years ago, in the 26th volume of NEETRAC News, we released an article about Baseline Project #07-244: Performance Evaluation of Integral Disconnect Switches for Single Phase Revenue Meters (see below). The results of this project represent our current best understanding of the issues as there has not been any subsequent baseline work. An article on the next page (NEETRAC PRJ17-208) discusses our investigation of the surge environment that these meters see when installed today.

Many utilities are in the request for proposal or final selection phase for advanced metering initiatives (AMI). Many of the new AMI revenue meters will contain integral connect / disconnect switches for remote operation to eliminate call-outs to disconnect or reconnect an electric service.

These switches, which are contained within the compact space of a revenue meter, should be thoroughly evaluated to minimize any risks to the customer premises from overheating / fires. The projects Technical Advisors selected five models of revenue meters with 200 A integral disconnect switches for evaluation. Existing test standards were reviewed and tests were developed and performed to evaluate heat rise, load break and through fault capabilities of single-phase revenue meters with integral switches. This project provides a comprehensive review of the performance of remote connect / disconnect meters.

Five areas were recommended to ANSI C12.1 to address requirements for Integral Disconnect Meters: heat rise/cycling test, accuracy vs. temperature, through fault performance, closing into fault, and not closing into energized load side.

Baseline Project Recently Extended

The following Baseline project was extended at the May 2021 Management Board Meeting. The project will continue for another year.

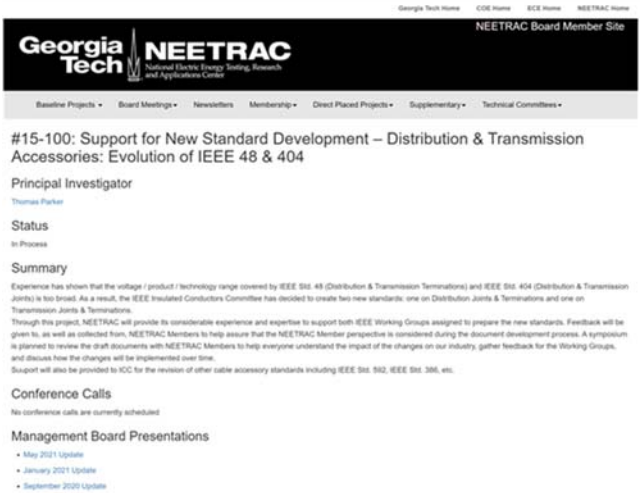
Support for Standards Development: Transmission & Distribution Cable Accessories

Baseline Project Number 15-100

PI: Thomas Parker, thomas.parker@neetrac.gatech.edu

IEEE currently has two separate standards for qualifying underground cable system joints – IEEE 404 for joints and IEEE 48 for terminations. This makes qualifying joints and terminations in one test exceedingly complicated. These standards also include both transmission and distribution test protocols, which further complicates the process.

The IEEE Insulated Conductors Committee has decided to create one standard for distribution cable accessories (joints and terminations) [IEEE 48404.1] and one for transmission cable accessories [IEEE 48404.2]. In this project, NEETRAC will provide support to the working groups writing these new standards and revisions of other IEEE cable accessory standards such as IEEE 386 and IEEE 592 by drawing on NEETRAC lab testing experience and soliciting input from NEETRAC Members.



Refer to the NEETRAC project website (above) for up-to-date information about the progress of the working groups.

Baseline Projects Recently Completed

The following Baseline projects closeout were presented at the May 2021 Management Board Meeting. The reports will be finalized and distributed to eligible Members in the coming months.

Lightning Risk Environment for Distribution Equipment

Baseline Project Number 17-208

PI: Ray Hill, ray.hill@neetrac.gatech.edu

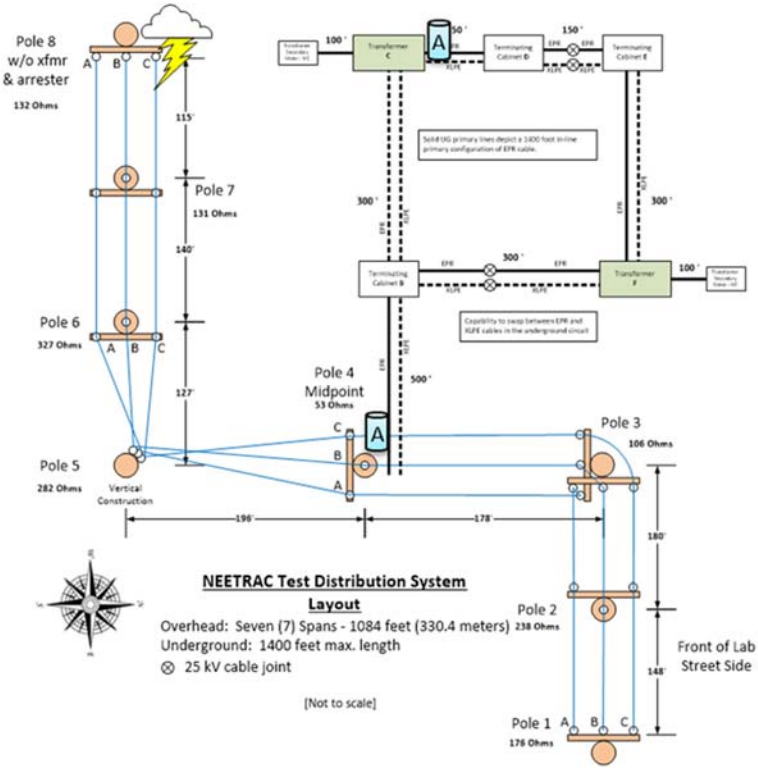
Electrical surges impact the life of all electrical devices and systems. The degree of this impact depends on the magnitude, duration, and any cumulative degradation on the device. Surge protective devices (arresters, surge suppressors) are installed to reduce, but not eliminate this exposure. This feature is becoming ever more important as the reliability, electric vehicles, computer systems, etc; play an increasingly central part of people's lives.

Lightning surge propagation from the overhead line through an underground distribution cable system and finally to the low voltage secondary system is not completely understood. This is due to the complexity of the interconnected systems and the reflections that occur.

Questions remained:

- How do the surge reflections interact with each system and each other?
- What time is required for the surge(s) to decay to tolerable levels?
- What is the **risk** to the high voltage primary and downstream, unhardened equipment (PV arrays, inverters, EVs, wind turbines, underground water wells, etc.)?

The purpose of this project was to better understand the risks caused by and the characteristics of lightning surges (waveforms and duty cycle) impinging on electrical equipment at any location throughout interconnected primary (overhead and underground) and secondary systems with branch circuits.



To implement this investigation, the scope of this project was to impulse, record, and study lightning surge propagation and interaction from the overhead line through an underground distribution cable system and on through the low voltage secondary branch circuits using NEETRAC's overhead and underground distribution system (See left).

Ten different case studies were performed involving different underground cable insulations, the use and non-use of lightning arresters, various lengths of secondary branch circuits, grounded and ungrounded distributed resource secondary branch circuits, and nearby lightning ground strike scenarios.

The tests provided many insights, a few are included on the next page; more details are in the Executive Summary.

Cont'd on next page

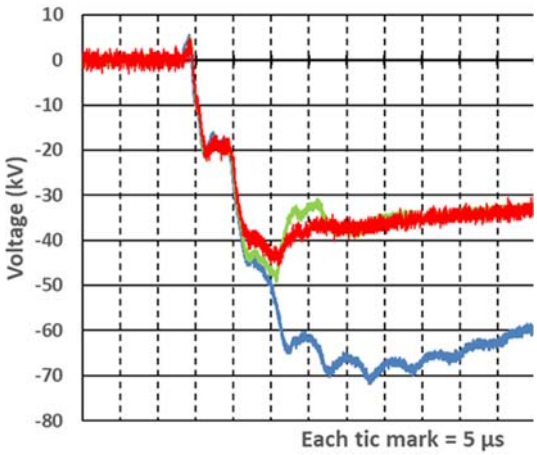
Lightning Risk Environment for Distribution Equipment - Cont'd

The Overhead System – Conducted Surges (Direct Lightning Strikes):

- Within the conducted surge has two components, one above and one below the "corona inception voltage" of the overhead line. The component above corona inception slows down rapidly. However, the one below continues and will interact with whatever is connected to the line.
- Arresters at any overhead / underground system junctions will reduce the overall surge past the junction on the overhead line. Importantly however, they do not protect the overhead line from the reflected surge propagating back from the junction.

The Underground System – Conducted Surges:

- The surge impedance mismatch at the overhead / underground system junction results in only a small portion of the higher frequency surge from the overhead line coupling into the underground system. However, the voltage peak associated with lower frequencies still propagates.
- Arresters at the junction reduce the voltage peak on all transformers within the underground systems and secondary circuits.
- Without arresters, the underground system sees many internal reflections (blue curve) which "trap" the surge. This will eventually be attenuated. Arresters reduce the reflections and the voltage magnitude (green and red curves).



Nearby & Remote Lightning Strikes Scenarios:

- All of the "nearby" lightning ground strike scenarios, when extrapolated to 30 kA, would result in voltage levels *exceeding* the transformer primary's 125 kV BIL rating of this 25 kV system.
- In all of the cases investigated here, the majority of the meter and branch circuits experienced voltage peaks greater than known product design testing levels. The levels are sufficiently high to interfere with the performance of computers, domestic DER, vehicles etc.

Safety Moment

Personal protective equipment (PPE), safety protocols, and grounding solutions for high voltage, 60 Hertz ac protection were not necessarily effective against ground potential rise (GPR). This is due to high voltage, high frequency electric discharges such as high voltage impulse testing and cloud-to-ground lightning discharges during thunderstorms.

Cable System Rejuvenation Forum

Baseline Project Number 16-048

PI: JC Hernandez, jean.hernandez@neetrac.gatech.edu

Cable system rejuvenation/rehabilitation is often offered as a cost efficient alternative to cable system replacement. This "rejuvenation" process includes a series of actions that have been used for a long time to improve distribution cable system reliability and are generally well thought of by established users.

The premise of this technology is that the condition of the whole cable circuit is upgraded so the work activities can be capitalized. Many NEETRAC Members still had questions about the effectiveness and practicality of this process. Therefore, to enhance the knowledge / understanding / awareness in this area, NEETRAC facilitated a "Rejuvenation Users Group" to establish a "state-of-the-art", fact-based overview of the process.

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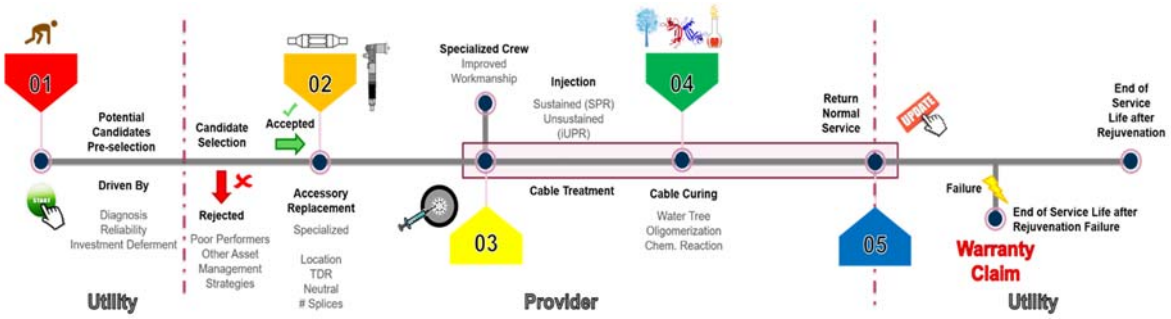
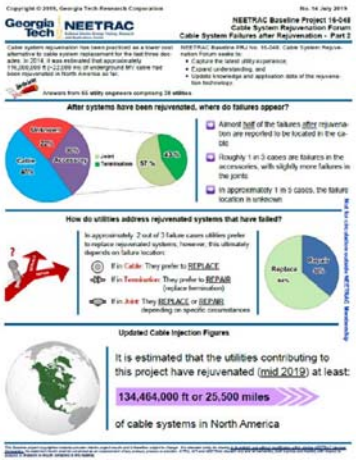
Baseline Projects Recently Completed - Cont'd

Cable System Rejuvenation Forum - Cont'd

One of the major outcomes of the project feedback was the confirmation and documentation of all of the important elements of the cable system rejuvenation process (see image). The process has responsibilities for both the technology provider and the utility. Moreover, although there is a tendency to focus on injection (water ejection, condition assessment of the neutral, and injection of a chemically reactive organo silane fluid), there is also the element from replacement of accessories (terminations and joints). A key enabler is that all the activities are undertaken by trained technicians such that the activities could be warrantied.



The approach used to develop the knowledge for this project was a novel one for NEETRAC - input from Members was collated to develop a fact-base and guide the direction of subsequent surveys. Some important findings include:



- By 2020, 53% of utilities had deployed rejuvenation at some time or other: NL2
- Engineers generally do not believe that injection restores cables to "as new" condition: NL3
- Major causes of "walkaways" or "no rejuvenation" are Neutral Corrosion and Number of Splices: NL5
- 50% of the service failures after rejuvenation occur in cable sections: NL14
- The failure rate after successful rejuvenation has been estimated: NL15

In addition, there are at least two developments in this space worth following:

- Development is underway on an "entity standard" – no major user input being included; no draft available for review.
- Providers are suggesting possibility of injection for strandfilled conductors – no data or experience has been reported by the TAs.

The major project conclusions are considered to be:

1) Rejuvenation is much more than simply injecting the cable (see process diagram).
    - Condition assessment before/during injection
    - Accessory replacement and system upgrade
    - Identification of poor performer candidates that are rejected
2) Average costs of the rejuvenation programs were reported to be notably higher than represented at project initiation.
3) There is important concern on how to quantify technical / economic benefits against other (replace / wait & see) asset management strategies.
4) Assessing rejuvenation performance is challenging due to how utilities record system outages, which cannot be easily correlated to a specific failure event and hence rejuvenation activity.

Technical Advisor Participation

Member employees have the opportunity to serve as Technical Advisors on NEETRAC collaborative (Baseline) projects. In this role, they provide guidance that maximizes the value of the project to their company and to the Membership as a whole.

What value do you receive from serving as a Technical Advisor?

- You receive project results as soon as they become available
- You have first hand information on the progress / development of the project
- You network with other Technical Advisors from NEETRAC utility and manufacturing Member companies through project conference calls
- You suggest ways that the project addresses issues specific to your company
- You have direct access to analysis and interpretation of project data
- You have the opportunity to provide input on the project deliverable

What does NEETRAC expect of Member Technical Advisors?

- You represent the perspective of your company
- Along with your Management Board Representative, you solicit input from others in your company to help maximize the value of the project
- Together with your Management Board Representative, you disseminate the findings of the projects widely within your company
- You review the project deliverables (presentations, software, and final report)
- You raise any concerns (technical or commercial) during the course of the project

To become a Technical Advisor for the new projects summarized in this newsletter or any other NEETRAC Baseline project, please email Suzanne Schmidle at suzanne.schmidle@neetrac.gatech.edu with your contact information and the project for which you'd like to volunteer.

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Management Board Meetings

The next three Management Board meetings have been scheduled for the following dates:

September 22 - 23, 2021
January 26 - 27, 2022
May 18 - 19, 2022

For details, please visit the Member Section of the NEETRAC website at www.neetrach.gatech.edu.

2021/2022 NEETRAC Member Management Board Representatives

1. Alumaform……. Pete Landsgaard
2. Ameren……. James Huss
3. American Electric Power…….. Jim Salerno
4. BC Hydro……Fred Dennert
5. Borealis Compounds, Inc.……..Susan Song
6. Consolidated Edison…… Frank Doherty
7. Dominion Energy…….. Liz Sullivan
8. Dow Chemical Company……..Paul Caronia
9. DTE Energy……Naera Haghnazarian
10. Duke Energy……...Chris Fletcher
11. Eaton…….. Alan Yerges
12. Exelon…….. Lisa Perrone
13. FirstEnergy……..Randy Coleman
14. Gresco Utility Supply……..Brad Schafer
15. Hubbell Power Systems……Charles Worthington
16. LS Cable & System……Tim West
17. Nova Scotia Power……Jim McFadgen
18. NRECA……Reed Cooper
19. Okonite……...Bill Crawford
20. Pacific Gas & Electric…….. Jim Gill
21. PPL Corporation……..……Chris Fatzinger
22. Prolec GE…….. Carlos Gaytan
23. Prysmian Group……Bill Temple
24. Public Service Electric & Gas..…... Ed Gray
25. Rauckman Utility Products……Jim Rauckman
26. S&C Electric……..Marshall Mauney
27. San Diego Gas & Electric……..…. Christian Henderson
28. Smart Wires…….…… Haroon Inam
29. Southern California Edison……Alan Kasanow
30. Southern Company……..Michael Pearman
31. Southern States, LLC…….. Joe Rostron
32. Southwire Company……... Yuhsin Hawig
33. Tacoma Power……..Joe Rempe
34. TE Connectivity……Brian Ayres
35. TVA…… Steven Coley
36. Viakable…… Raul Garcia
37. WEC Energy Group…….. Michael Smalley